VOL. V, PP. 49-58, PL. 20 APRIL 29, 1893

THE

NATIONAL GEOGRAPHIC MAGAZINE

RAINFALL TYPES

OF THE

UNITED STATES

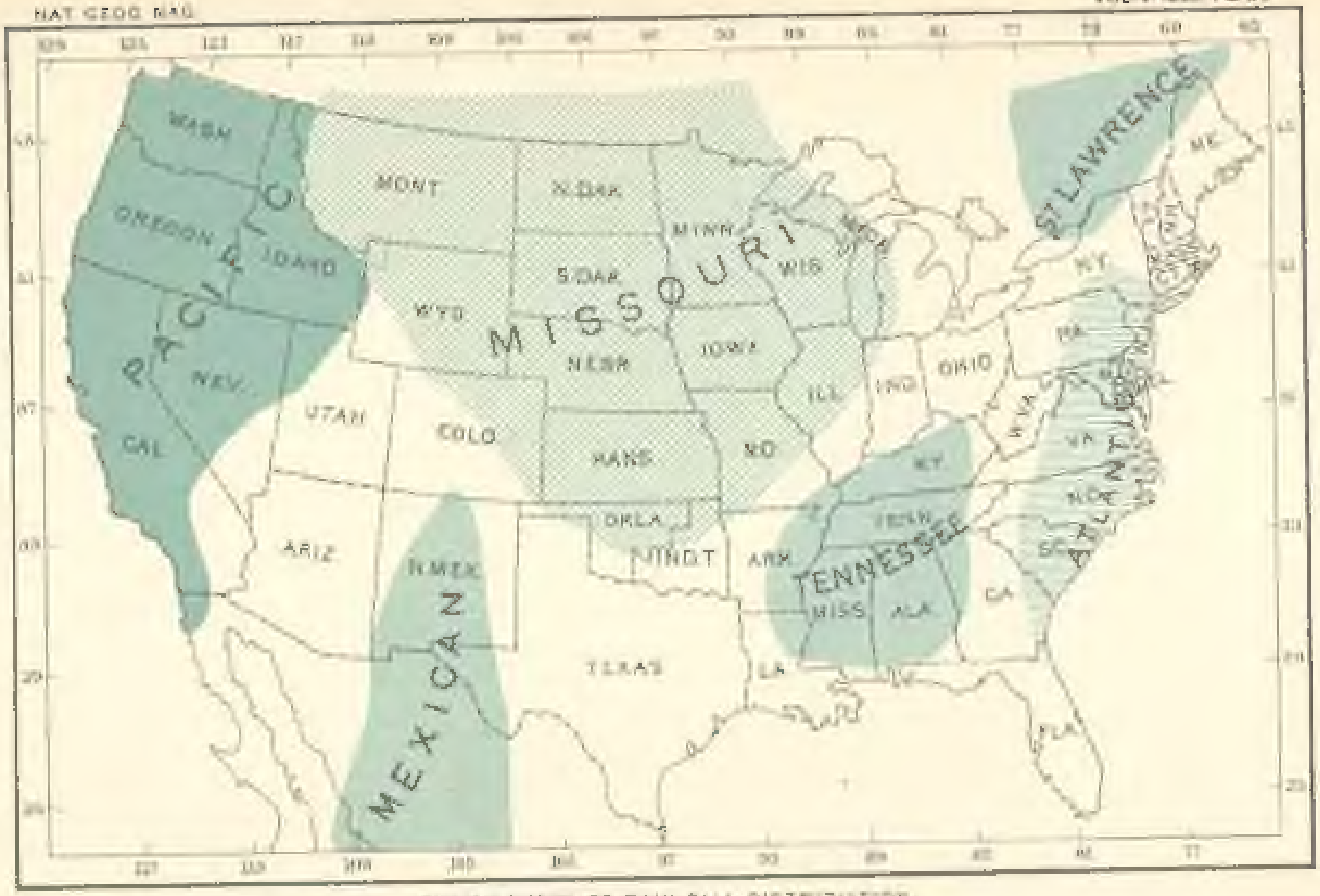
ANNUAL REPORT BY VICE-PRESIDENT

GENERAL A. W. GREELY

WASHINGTON

PUBLISHED BY THE NATIONAL GEOGRAPHIC SOCIETY

PRICE 25 CENTS



SIMPLE TYPES OF RAIN FALL DISTRIBUTION

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GENERAL A. W. GREELY

(Presented before the Society January 6, 1893)

In carrying out the announced policy of the National Geographic Society with regard to annual contributions from its vice-presidents in their respective domains of geographic science, it has seemed advisable for the vice-president of the "Geography of the Air" to place before the Society this year a special paper.

The subject selected is the typical distribution of rainfall in the United States and contiguous territory, and an attempt has been made to treat the subject in such a manner that it may be a permanent contribution to the physical geography of the United States. It goes without saying that a paper covering twenty millions of square miles cannot go much into detail, but it is hoped that the treatment, while general, is yet such as to give definite and clear ideas on the subject treated.

This paper does not consider the distribution of rain from the standpoint of the mean annual precipitation, does not dwell on the variability or unequal amounts in consecutive years, omits to discuss the distribution from the standpoint of varying elevations, and is silent on the question of distribution with reference to frequency or absence of excessive rains of periodic or non-

dental occurrence. It confines itself to a question of great and sometimes vital importance, to the characteristic distribution of precipitation throughout the year, and, as is believed, presents a successful analysis of the average fluctuations from month to month, so that for the first time a satisfactory presentation is possible of all the simple rainfall types and of most of the composite types which obtain over the broad expanses of the inhabited portions of North America.

The necessity of careful and scientific study of climatic conditions in connection with prospective enterprises, whether pertaining to agriculture, commerce, navigation, or to special industries, has become obvious the past few years through the spur of competition. Among such conditions, that of rainfall distribution throughout the year is one of the most important. With relation to agriculture, it is essential to know whether precipitation comes at such seasons as to be a benefit or a detriment to the proposed crop. In the initiation of irrigation enterprises not only are the questions of guarding against excessive and torrential rainfalls on one hand and of tiding over temporary droughts on the other of importance, but, further, whether the most copious precipitations occurs in such months as to afford water at seasonable periods, or the rain comes at such times that it must be stored for many months with consequent loss from seepage and evaporation. Similarly, this question of distribution of rain throughout the year affects most potently other business interests of importance.

That these questions are of current and practical value is evident to every thoughtful man, and that their earlier elucidation and the publication of results would have been an extended benefit cannot be questioned. Take agriculture, for instance, which in eastern Colorado is pursued under difficult conditions wherever irrigation is impracticable. Failure of crops very frequently resulted until observation showed that a scanty rainfall in June is the rule in that section, and that by planting at a certain season the injurious effects of the June drought could be mitigated.

Nor is the necessity of a definite and accurate determination of the typical forms of annual precipitation in the eastern part of the United States less obvious, since the latest text-book on meteorology in use in the United States, that of Loomis, contains the statement that "Throughout most of the United States east

of the Rocky mountains the rain is pretty equally distributed through the different months of the year, but the rain of summer is *everywhere* somewhat greater than that of winter, including melted snow.[1]

In reality the whole section of country, about 200,000 square miles in extent, dominated by the Tennessee type of rainfall experiences a larger precipitation in winter than in summer, the excess averaging in northern Alabama and southern Kentucky about 10 per cent, in western Georgia and in Tennessee over 20 per cent, and in southeastern Arkansas and northern Louisiana from 40 to 50 per cent (plate 20).

I have pointed out elsewhere the vital importance of a favorable distribution of rainfall to certain sections of the country, where this favoring type of precipitation has proved to be one of the great bases on which rests the national prosperity of this great republic. Allusion is made to the great grain-producing sections throughout the water-sheds of the upper Mississippi, the Missouri, the Red river of the North, comprising the Dakotas, Minnesota, Kansas, Nebraska, Iowa, Missouri, Wisconsin and Illinois. Over the greater part of this immense area the annual rainfall is very materially less than that of the regions to the eastward or southward, but, most fortunately for the country, about three-fifths of the rainfall for the entire year occurs opportunely through the period when it is most beneficial to crops, from April to July, inclusive. A less favorable type of rainfall, the Mexican or the Saint Lawrence, for example, would render growing of grain unprofitable throughout the whole of this favored region.

It remains to briefly indicate the few types of simple rainfall with the localities to which they refer, and to the composite types occurring through the overlapping and interference of simple types.

Composite types must prevail where two simple types are not separated by high mountain ranges, and thus gradually shade or merge into each other. One dividing line, the Rocky mountain range, separates by its crest, if not absolutely, yet quite sharply and definitely, the Missouri type in Montana and Wyoming from the Pacific type in Idaho and Washington.

The term *simple* has been applied to those rainfall types which can be graphically expressed by a curve with a single bend or inflection. The average monthly amounts pass from the single

maximum to the single minimum through uninterruptedly diminishing quantities, and thence rise with unbroken increase to the maximum. The *composite* types are those in which the graphic expression would be shown by two inflections, from a primary maximum through the minimum to a secondary maximum and secondary minimum.

In general terms it may be said that each simple type of rainfall in the United States appertains to a single body of water for its resulting precipitation; thus the Pacific type comes directly from the Pacific ocean, the Mexican type from the gulf of California, the Tennessee type from the gulf of Mexico, and the Atlantic type from the Atlantic ocean. In the Missouri type, however, two sources are evident—primarily the gulf of Mexico, and secondarily, and to a much larger degree than has been usually advanced, Hudson bay and the chain of great American lakes.

In treating the distribution of rainfall throughout the year it is evident that the unequal lengths of the different months affect somewhat the accuracy of direct inter-comparisons of normal monthly rainfalls. There fell under my observation lately a curve showing such inter-comparisons which proved misleading, as it showed a decrease of rain from January to February and an increase from February to March, when in reality, as shown by the average amount daily for each month, the rainfall became more copious from January to February and from February to March.

In this discussion the rule has been followed of obtaining the normal daily rainfall by dividing the normal yearly rainfall by 365.25. In like manner the average daily rainfall of February has been found by using 28.25 as a divisor, and the largest months by using 31. In this paper, for the sake of brevity and in order to avoid repetition, it is to be explained that the term "normal daily rainfall" is applied to the mean determined from the annual precipitation, and that the terms "January rainfall, March rainfall," etc, unless otherwise explicitly stated, mean the average daily amount determined for the month in question by the methods above indicated.

The best defined type of rainfall within the limits of the United States is that which dominates the Pacific coast region; hence the specific name "Pacific" herein applied. In general terms it may be said to dominate British Columbia, Washington,

Idaho, Oregon, California, Nevada and western Utah; in other words, the great interior basin and the entire Pacific water-shed from British Columbia to Lower California, excluding the section draining into the gulf of California. The characteristic features are very heavy precipitation during midwinter, and an almost total absence of rain during the late summer.

The infrequency of summer rain is marked in British Columbia, and thence southward it becomes steadily more pronounced, passing through the gradations of a single rainless month in northern California, then two and three to the culmination of four rainless months in a considerable part of southern California and western Nevada. There is a tendency in the upper half of the San Joaquin valley and thence southward into the western part of San Diego county for rain to cease about a month earlier and to remain absent a month later than over the rest of the Pacific coast region, the dry season being from June to September, inclusive, and being usually unbroken even by a passing shower.

Eastern Nevada appears to share freedom from rain during July, but the autumnal rains appear in September or earlier, under the influence in the southern part of that state of the Mexican type projecting northward. The marked tendency of the winter rains to continue into spring is evident in Washington, whence it shades with diminishing persistency to northern California and northwestern Nevada.

It may be remarked that in the Pacific coast region the amounts of rain vary very greatly, according to the topography of the section and the distance from the ocean; so that the interior depressions, such as the Sacramento, San Joaquin and other valleys, particularly those parallel with the coast, have a smaller rainfall than either the coast itself or the Sierra Nevada and other mountain ranges to the eastward.

These variations in the total rainfall do not, however, affect the distribution throughout the year, which is typically Pacific throughout the whole region.

As might be expected where the rainfall is very small, a single month of excessive precipitation occasionally increases the rainfall so as to be misleading. For instance, it is apparent from inspection that the greatest normal precipitation is that of December at both San Diego, California and Hallock, Nevada; yet excessive rainfalls of 9.63 inches in February, 1884, at the former

plane, and 4.18 inches in February, 1870, at the latter, three the February daily precipitation slightly above that of December. Of the following examples of the Pacific type, five are drawn from the interior, viz, Spokane, Washington, records of 12 years; Delano, California, 15 years; Boise City, Idaho, 22 years; Promontory, Utah, 21 years; Hallock, Nevada, 21 years; and three from coast stations, viz, Astoria, Oregon, 20 years; San Diego and San Francisco, California, each 41 years.

Normal daily Rainfall and monthly departures therefrom.

(Values are in fractions of an inch.)

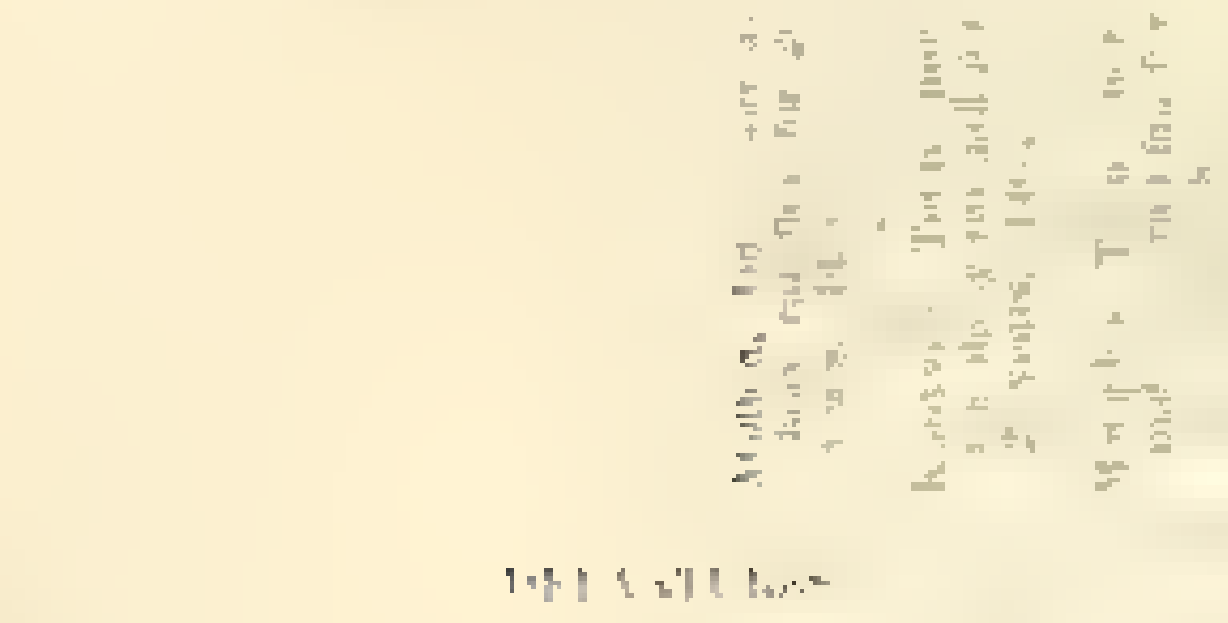
	STATIONS.							
DEPARTURES.								
January								
February								
March								
April								
May								
June								
July								
August								
September								
October								
November								
December								

Another example type of rainfall is that which for a previous paper I designated as the "Texas-Texan," from the fact that it dominates extreme western Texas beyond the Pecos river. On further investigation it proved to prevail in the province of

[illegible]

[illegible]

The general character of the Missouri type as pertains rainfall is determined by the records of Sacramento, the main being that of the growing time. In Nebraska only about one-half of the yearly precipitation can be depended on to be in the growing season. In April, however, the percentage of the annual rainfall is 11 on May 17, on about 10 on 1 June 10, making almost 40 per cent for these four months. In other words, three-fifths of the yearly rainfall comes most opportunely during the period when it is most beneficial to the growing crops. It is well known that the annual rainfall is usually not [illegible]



Type of stone implements of the Red Paint People of New England, probably made from the pebbles they found on the beach, as the "Deerfield" type is generally the "Connecticut" type. The